

December 16, 2016

Wendy Cheung
US EPA
Mailcode: 8P-W-GW
1595 Wynkoop Street
Denver, CO 80202

RE: Well Completion Report for ECCV Well DI-2 (EPA UIC Permit No. CO12143-08424)--
Amendment 1

Dear Ms. Cheung,

Attached please find Amendment 1 for the well completion report for the East Cherry Creek Valley Water and Sanitation District UIC Class I injection well DI-2. Included are interpretations of the Temperature log, and Cement Bond Logs (CBL).

Sincerely,

Pat OBrien, CPGS, PE

1. Longstring Cement Bond Log Interpretation.

Attached is a copy of the cement bond log run on the 7.625 inch longstring casing cemented in a 9.875 inch borehole which runs from ground level to 9055 feet from KB. Following the procedures in the EPA "Ground Water Section Guidance No. 34: Cement Bond" document, we have prepared an analysis for this CBL.

The log was run on July 1, 2016. The purpose of the CBL is insure that the well is cemented so that salty formation water and injectate brine in the injection zone (from 9056 feet to 10,100 feet) are not able to migrate upward through the cemented annulus and enter into the drinking water aquifer zone (from ground level to 1694 feet).

The objective of the CBL log analysis is to show there is at least one zone with an 80% (or higher) bond index for a continuous 36 foot interval.

After reviewing the log, we defined a 100% bond index value of 1.8 mv. Reliance Oilfield Services then obtained a free pipe, 0% bond value of 59 mv. Using the Guidance Document 34 equation, we determined the 80% bond index was 3.53 mv.

We next defined intervals that were more than 36 feet long and had a bond index of 80% or more. These depths to, and thickness of, these intervals are presented in Table 1 below.

Table 1. Longstring Intervals with 80% or Greater Bond index.

Interval depth (feet from KB)	Interval Thickness (feet)
3168-3208	40
3236-3302	66
3346-3394	48
3416-3485	69
3636-3698	62
3791-3854	63
3855-4118	263
4147-4198	51
4334-4377	43
5494-5600	106
5838-5888	50
5901-5962	61
6046-6116	70
6117-6166	49
6213-6279	66
6310-6385	75

Therefore, based on the 17 zones meeting the 80% bond index and the continuous interval thickness of 36 feet or greater, the cement job is acceptable.

2. Surface Casing Cement Bond Log Interpretation.

Attached is a copy of the cement bond log run on the 10.75 inch surface casing cemented in a 14.75 inch borehole which runs from ground level to 1776 feet from KB. Following the procedures in the EPA “Ground Water Section Guidance No. 34: Cement Bond” document, we have prepared an analysis for this CBL.

The log was run on June 21, 2016. The purpose of the CBL is to insure that the well is cemented so that salty formation water and injectate brine in the injection zone (from 9055 feet to 10,100 feet) are not able to migrate vertically or horizontally through the cemented annulus and enter into the drinking water aquifer zone (from ground level to 1694 feet).

The cemented surface casing zone between ground level and 1776 feet is not as critical as the longstring cement zone in protecting the freshwater aquifers from invasion by brine for three reasons:

1. This zone is protected from horizontal brine migration by being double cased and double cemented, with one cement zone between the 10.75 inch casing and the 14.74 inch borehole and a second cemented zone between the 7.625 inch longstring casing and the 10.75 inch surface casing.
2. The freshwater aquifers are also protected from being invaded vertically by brine by the excellent cemented zone behind the longstring casing between 1776 and 9055 feet.
3. The freshwater aquifers are also protected from horizontal brine invasion by constantly monitoring the annular pressure between the 5.5 inch production tubing and the 7.625 inch longstring casing which confirms the integrity of the 7.625 inch casing.

That said, after reviewing the log, we defined a 100% bond index value of 1.5 to 2.0 mv. Reliance Oilfield Services then obtained a free pipe, 0% bond value of 47.9 mv. Using the Guidance Document 34 equation, we determined the 80% bond index was about 3.77 mv. Note there is some variance in the travel time on the temperature log which affects the 100% bond value.

We next defined the longest intervals with a bond index of 80% or more. The depths to, and thickness of, these intervals are presented in Table 2 below.

Table 2. Surface Casing Intervals with 80% or Greater Bond index.

Interval depth (feet from KB)	Interval Thickness (feet)
1490-1503	13
1531-1546	15
1595-1608	13
1625-1642	17

There are no continuous 80% bond intervals that are longer than 54 feet mentioned in the EPA Guidance document No. 34. However, we believe such an interval is not required because of the 3 reasons mentioned above.

3. Temperature Log Interpretation.

On August 9, 2016, Reliance Oilfield Services ran a temperature, gamma, casing collar locator log on the entire length of the well. The purpose of this initial temperature log is to use as a base for comparison with future temperature logs to document flow and temperature changes with time. Secondly this log can be used to look for temperature anomalies. In order to let the well temperature equilibrate downhole, we killed the well with brine on August 5 and shut the well in for 48 hours (August 6 and 7, 2016). We tried to run the log the next day, but could not because the well had pressured up during the shut in period. We again killed the well with 520 barrels of weighted brine on August 8. After about a 20 hour shut in period, we were able to run the temperature log on August 9. Note the log is measured from KB.

We tabulated the temperature gradient in 500 foot increments in the unperforated longstring from ground level to 9000 feet (near the top of the 4.5 inch liner). In the perforated zones, we tabulated temperature gradients more frequently and defined temperature anomalies (Table 3).

The temperature gradient gradually increases from about 9 deg F/1000 ft. at 500 feet to about 30 deg F/1000 feet at 8000 feet. From 8000 to 9000 feet the gradient drops to about 20 deg/1000 feet. In the perforated zone (9072 feet and below), the gradient varies significantly with depth.

In two zones above the perforated zone—from 7970 to 8070 and from 8150 to 8300--there is very little change in temperature. This may be due to the cold weighted brine used to kill the well.

There is some cross flow and/or zone swapping in the perforated zone. These anomalies are likely caused by the variations in pressures between perforated zones. The temperature anomalies noted are as follows:

1. A 5 degree gain from 9010 to 9060 near the top of the liner, which may be due to the heat transfer from the 4.5 inch liner acting as a heat conductor from the higher-temperature perforated zones below.
2. No temperature change from 9080 to 9180 (in the heart of the Lyons Formation), likely due to invasion of cooler water from above.
3. There is an abrupt gain of 3 degrees in a 35 foot zone from 9600 to 9635 feet, likely because it is receiving hot water from below.
4. There is also a loss of 3 degrees across the zone from 9635 to 9770, likely because it is receiving colder water from above.
5. The zone from 9770 to 9950 has a very low gradient of 2.3 deg/1000 feet indicating it may also be receiving colder water from above.

Note that, due to unknown variables involved, there are several different interpretations that may explain the anomalies listed above.

Table 3. Temperature Log Data

Zone Depth (feet from KB)	Temp. Gradient (Deg F/1000 feet)	Comments
0-500	9.4	
500-1000	9.2	
1000-1500	14	
1500-2000	13.6	
2000-2500	14.4	
2500-3000	17.6	
3000-3500	18.6	
3500-4000	21.4	
4000-4500	22.6	
4500-5000	21	
5000-5500	22.2	
5500-6000	22	
6000-6500	25.4	
6500-7000	24.8	
7000-7500	24.6	
7500-8000	30.4	No temp change from 7970 to 8070
8000-8500	20	Very low temp change from 8150 to 8300
8500-9000	20.4	5 deg. Gain from 9010 to 9060 (liner top)
9080-9180	0	No temp change from 9080 to 9180 (Lyons)
9200-9300	27	
9300-9400	32	
9400-9500	21	
9500-9600	9	
9600-9635	86	3 deg. gain (receiving hot water from below)
9635-9770	-22.2	3 deg. loss (receiving cold water from above)
9770-9950	2.3	Virgil, Admire, Missourian very low gradient